REMOTE TEMPERATURE MONITORING AND ANALYSIS OF THERMOFORMING PROCESS.

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ABSTRACT

Web-based Graphical User Interface for Manufacturing Process is one of the latest features to be implemented on most industry's machine recently due to availability of wide Internet network. The concept of connecting object to Internet network has been introduced by Kevin Ashton under the term of “Internet of Thing”. In this project, temperature monitoring devices for thermoforming machine heating section is being design and builds to measure temperature respond of radiation and convection heat transfer using thermocouples. The focuses on this project is to produce low cost data acquisition system using the spark core microcontroller that can display and record data remotely. It was found that using this system it enables far distance monitoring operation yet only suitable for certain type of process that perform at low response.

ABSTRAK

Antara muka pengunaa berasaskan grafik mengunakan komponent laman web di adaptasi untuk proses pembuatan adalah salah satu ciri-ciri terkini yang dilaksanakan pada kebanyakan mesin industri baru-baru ini kerana adanya rangkaian internet lebar. Konsep menghubungkan objek ke rangkaian internet telah diperkenalkan oleh Kevin Ashton mengunnakan istilah "Internet of Thing". Dalam projek ini, peranti pemantauan suhu pada bahagian pemanasan alat “thermoforming” di reka bentuk dan dibina untuk mengukur suhu radiasi dan konveksi pemindahan haba menggunakan penganding suhu. Fokus projek ini adalah untuk menghasilkan peranti kos rendah sistem merekod data menggunakan mikropengawal model Spark Core yang boleh memaparkan dan merekod data pada jarak jauh. Ia telah mendapati bahawa menggunakan sistem ini, membolehkan operasi pemantauan pada jarak jauh tetapi hanya sesuai untuk jenis proses tertentu yang berlaku pada tindak .

TABLE OF CONTENTS

	Page
EXAMINER'S DECLARATION	ii
SUPERVISOR'S DECLARATION	iii
STUDENT'S DECLARATION	iv
ACKNOWLEDGEMENTS	v
ABSTRACT	vi
ABSTRAK	vii
TABLE OF CONTENTS	viii
LIST OF TABLES	xi
LIST OF FIGURES	xii
LIST OF ABBREVIATIONS	xiv

CHAPTER 1 INTRODUCTION

1.1 Project Background	1
1.2 Problem Statement	2
1.3 Project Objective	2
1.4 Project Scope	2
1.5 Thesis Outline	3

CHAPTER 2 Literature Review

2.1 Introduction.	4
2.2 Internet of Thing.	4
2.3 Spark Core v1.0 Microcontrollers.	5
2.4 Cloud server	6
2.5 Sensor.	7
2.5.1 Thermocouple.	7
2.6 Data acquisition	8
2.7 Signal Conditioning.	8
2.8 Multiplexer Circuit.	9

	2.8 Offset Calibration	10
CHAPTER 3	**Methodology**	
	3.1 Project Flowchart	11
	3.2 Firmware Programing	12
	3.3 Firmware Programing	13
	3.4 Hardware design	13
	3.3.1 Block Diagram	13
	3.3.2 Circuit Design	15
	3.5 Experimental Set up	15
CHAPTER 4	**Result and Discussion**	
	4.1 Result	*19*
	4.1.2 System Performance.	*19*
	4.1.3 Temperature Responds	*20*
	4.2 Discussion	*22*
CHAPTER 5	**Conclusion and Recommendation**	
	5.1 Conclusion	24
	5.2 Recommendation	24
REFERENCES		26
APPENDICES		
A	Microcontroller Datasheet	27
B	Analog Multiplexer 7HC4053	29
C	IC MAX6657 Datasheet	36
D	Omega engineering Thermocouple Specification	44
E	T-TYPE Thermocouple Reference Table	45
F	Firmware Coding	46

G	Data collected	53
H	Multiplexer circuit and PCB Layout	58
I	Project Gantt Chart	59
J	Turnitin Originality Report	61

LIST OF TABLES

Table No.	Title	Page
1.0	Truth Table For Multiplexer Output.	10
2.1	Result of Experiment 1	53
2.2	Result of Experiment 2	55

LIST OF FIGURES

Figure No.	Title	Page
2.1	Spark Core v1.0 Microcontroller.	5
2.2	Screenshot of web based GUI	6
2.3	Type-T Thermocouple.	7
2.4	Basic signal conditioning connection.	8
2.5	74HC4052 Function diagram.	9
3.1	Overall project Implementation flowchart.	11
3.2	Cloudduin Web Apps	12
3.3	Spark DEV IDE.	13
3.4	Block Diagram of the remote monitoring system.	13
3.5	Screenshot of multiplexer design process.	15
3.6	Overall Project Hardware.	15
3.7	Project circuit	15
3.8	Thermocouple Position on heating section.	16
3.9	Thermocouple Position for Experiment 1 on Thermoforming Equipment Heating section.	17
3.10	Thermocouple Position for Experiment 2 on Thermoforming Equipment Heating section.	17
3.11	Heating element cover	18
4.1	Thermocouple position on heating section for experiment 1.	20
4.2	Thermocouple position on heating section for experiment 2.	20
4.3	Temperature History for first experiment.	21
4.4	Temperature History for second	22

	experiment.	
4.5	Plastic sheet profiles under thermoforming process	23
6.1	Multiplexer schematic.	58
6.2	PCB Layout	58

LIST OF SYMBOLS

dBm	Decibel-milliwatts
$°C$	The degree Celsius
T_R	The temperature of the remote thermocouple junction.
T_{AMB}	The ambient temperature.
μV	MicroVolt
KB	Kilobyte
MHz	Mega hertz
Mbps	Megabit per second

LIST OF ABBREVIATIONS

ADC	Analog to digital converter
APP	Application
ARM	Advance RISC Machine
BIT	Binary digit
DAQ	Data acquisition system
EMF	Electromotive force
EPROM	Erasable programmable read only memory
GND	Ground
GUI	Graphical User Interface
I/O	Input or output
IEEE	Institute of Electrical and Electronics Engineers
IDE	Integrated development environment
IOT	Internet of things
Op-amp	Operational amplifier
RAM	Random Access Memory
ROM	Read-only memory
SC	Seedbeck coefficient
TC	Thermocouple
V	Voltage
Vcc	Positive supply voltage
Vee	Emitter supply Voltage
V_{OUT}	Thermocouple output voltage
Vss	Negative Supply Voltage

Chapter 1

INTRODUCTION

1.1 Project Background

Implementation of latest technology in manufacturing process can improve productivity of the process. A lot of new features have been upgrade to manufacturing process system from year to year by engineer make the process more accurate, efficient, safe, and flexible related increase in the productivity. Latest microcontroller technology that integrated with wireless communication can be used as a platform to increase the monitoring capability.

Current assessable technology provides potential for remote integration and collaboration in manufacturing applications. The remote technology converts information and represent it in form of real-time visual information to the user which that can be accessed at different location and multi view display. This technology gives the advantage to prevent hazard of the emission or radiation where the machine operator will directly be exposed as he or she go near the machine to measure or operate the machine for certain cases.

For this project, a remote system to monitor the conventional thermoforming equipment will be developed and implement. The projects are improvement of conventional thermoforming equipment develop by previous student that used the wired data acquisition system to monitor the heat transfer on thermoforming process. The manual and decentralized monitoring system for this equipment can be considered as unproductive if the number of machine is high and being us for high scale production.

1.2 Problem Statement

In performing manufacturing process, machine operator facing difficulty in accessing the machine or equipment from different location and the monitoring process needs to done near the machine in identifying thermal characteristic of thermoforming process.

1.3 Project Objective

The objectives of this project are:

1. To develop hardware and software for remote monitoring system of thermoforming equipment.
2. To analysis the temperature responds on thermoforming process.

1.3 Project Scope

The scopes of this project are as follows:

1. Create software coding for monitor and control the thermoforming equipment.
2. Link the machine input and output data with the computer and mobile device remotely.
3. Analysis the temperature on thermoforming process that produces by the equipment.

1.5 Thesis Outline

This thesis is classified into five chapters. The contents of each chapter are summarized as below:

Chapter 1 briefs the introduction of the project. The background, objective, problem statement, scope of project summarizes the content of thesis are explained in this chapter.

Chapter 2 consist of the literature review that made from several journals and article that been refer which elaborates the recent research on the technology and also consist of the methodologies that has been applied in this project

Chapter 3 explains the hardware and software design of the project. In hardware design, will be focusing on the hardware that link between machine and display device. For software design, the programming of the GUI will be explained. The connections of hardware between the sensor and the thermoforming equipment are shown in circuit schematic diagram.

Chapter 4 will show all the results and the analysis of the project. All of the result obtains will be analyzed and the comment will be given based on the result getting.

Chapter 5 concludes the outcome of this project. It also includes the recommendations on this project for future works to improve the system.

CHAPTER 2

LITERATURE REVIEW

This chapter mainly about combining latest and previous information in this study which will summarize the important information regarding several fields involved in this project and it helps to elaborate certain term for understanding. Each category in this chapter will be discussed in detail about topics related which is microcontroller, internet protocol, web server, concept of data acquisition, multiplexer and sensor.

2.1 Introduction.

The combination of computers, multimedia and the Internet have provided great potential for remote integration and collaboration in business and manufacturing applications. Monitoring technique using the Internet can give advantage to the design and manufacturing productivity, economy, and speed, as well as provided collaborative real-time working (Hongbo Lan, 2009).

2.2 Internet of Thing.

The technology of traditional Internet has come to edge of maximize usage where it will fuse into a smart Internet of Things (IoT) exist by digitalized communication of various objects in the physical world. The IoT is generally set up of devices and objects contain a digital data processor or embedded that interact by other digital device such as mobile phone or personal computer using communication mechanism, mostly applying wireless connection.

The IoT giving the advantage of display unseen physical properties of the object which creating different way to interact. This creates new type of possibilities in internet application which make the thing's information able to be accessed globally on the network.

The term Internet of Things was coined and first used by Kevin Ashton over a decade ago to attributes by being an Internet application and handle the thing's information.

2.3 Spark Core v1.0 Microcontrollers.

In this project, the microcontrollers playing an extremely important role as to link between the equipment to graphical user interface. Spark core used STM32F103CB chip which is ARM 32-bit Cortex M3 based microcontroller as a central processing unit operate at 72 MHz. This microcontroller has been attached with Wi-Fi module model Texas Instruments SimpleLink CC3000 as to give ability to communicate thought IEEE 802.11 wireless protocol so the process of interfacing the microcontroller on the internet became easier. This Wi-Fi module has performance of transmitting power communicate +18.0 dBm at speed of 11 Mbps Complementary Code Keying and receiver sensitivity detect –88 dBm with 8% Packet Error Data at 11 Mbps. It has 8 digital I/O and 8 analog inputs with 12-bit ADC. The I/O pin configuration is shown in Figure 2.1. The microcontroller operates at 3.3V DC supply voltage connected with on board power regulator. It has 128 KB of Flash and 20 KB of RAM internal memory and 2MB of external flash EEPROM supplied by CC3000.

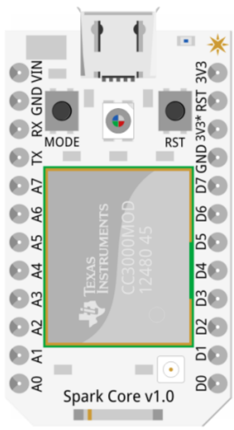

Figure 2.1: Spark Core v1.0 Microcontroller.

Source: Beri (n.d.). Spark Core Pin Diagram.
Reverted from http://docs.particle.io/assets/images/spark-pinout.png [Accessed 8 June 2015]

2.4 Cloud Server.

Cloud server works as a distribution platform to distribute data from machine to user. The resource for cloud server usage can be tuned by a decrease or increase accordingly, making it more cost-effective and more flexible to user. The capacity of storage and bandwidth can be automatically increased to match that demand without this needing to be paid for on a permanent basis.

The different of cloud server compare to dedicated servers, cloud servers can be run on a virtualization manager where it can control the capacity of operating systems so it is allocated based on a particular client if and when only it is needed. Cloud hosting provides multiple cloud servers which communicate with each particular client. Another advantage of cloud sever is that when there is a spike in network traffic usage due to load, the additional capacity of resource will be temporarily allocated by a host server until it is no longer required. As the cloud servers work synchronize with other cloud server. If one server down or fails, others server will take its place continues backup the task.

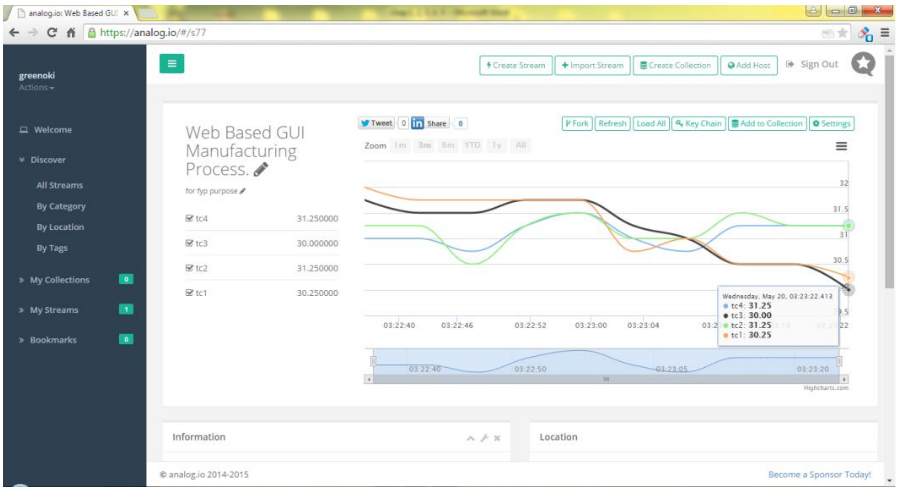

Figure 2.2: Screenshot of web based GUI

Source: analog.io(n.d) [screenshot]

Reverted from https://analog.io/#/s77[Accessed 8 June 2015].

For the graphical user interface output, this project used free internet application from website “www.analog.io” which display the recorded data as shown in figure 2.2 that store in the “data.sparkfun.com” database.

User needs to create an account to register before they can use this web application. For “data.sparkfun.com” application, user needs to configure the input variable and the stream title before it generate public and private key for the application. The public key is used as stream identification and the private key is used to push or modified in the database.

2.5 Sensor

2.5.1 Thermocouple Overview

Figure 2.3: Type-T Thermocouple.
Source: Omega Engineering(n.d.). Ready Made Insulated Thermocouple
Reverted from http://www.omega.com/Temperature/images/5TC_l.jpp

Thermocouple is a device that being constructed with two different materials such as copper and constantan (Type T). The two dissimilar metals are contact together at the end of both wires with weld bead. This device being used to detect and responds toward the temperature change. If there is a temperature different between bead and thermocouple end, the thermocouple will output electrical voltage. The voltage generated by this condition is called thermoelectric effect or Seebeck effect. The phenomenon is discovered by German Physicist T.J Seebeck in 1821.

The voltage output from thermocouple during seedbeck effect is express in Eq. (2.0).

$$V_{OUT} = (SC\ \mu V / °C) \times (T_R - T_{AMB}) \qquad (2.0)$$

2.6 Data acquisition

Data acquisition (DAQ) is the process of translating physical stimulus from the real world into electrical signals that are measured and converted into a digital representation for processing, analysis, and storage into computer memory (T. Sumphao, C. Thanachayanont, T. Seetawan, 2011).

2.7 Signal Conditioning.

Signal conditioning is a process transform real life input signal into the signal that can be read by data acquisition systems. Real input signal from the sensor is often has noise and produces the range of voltage that unsuitable for analog to digital converter (ADC) device to process. When using Thermocouple as sensor the output voltage from thermocouple produce the range in millivolt of output. This voltage need to be amplified at the range that suitable for ADC device. Figure 2.4 illustrate the basic signal conditioning connection for single thermocouple condition.

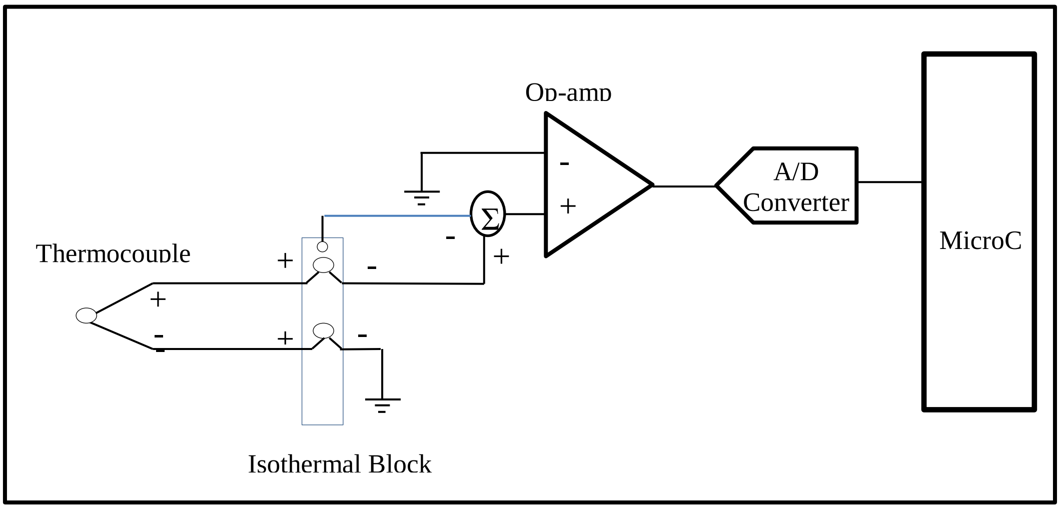

Figure 2.4: Basic signal conditioning connection.

2.8 Multiplexer Circuit.

Multiplexing is the universal term used to describe the operation of sending one or more analogue or digital signals over a common transmission line at different times or speeds**.** The 74HC4052 is a fast react silicon gate CMOS integrated circuit and is pin configuration is adaptable with the HEF4052B which suitable for this project. The IC is compliance with JEDEC standard no. 7A.

The 74HC4052 is dual 4-channel analog multiplexer with a common enable input (E). Each multiplexer has four separated inputs (nY0 and nY1) and single common output (nZ) control by two digital select inputs (Sn). Both channels will switch based on same digital select input. With E LOW, common output will enable according to the channel selected using S0 and S1 by condition low-impedance ON-state. With E HIGH, all output switches are in the high-impedance OFF-state, independent of S0 to S1.

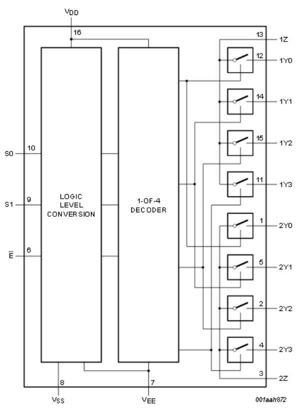

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Figure 2.5: 74HC4052 Function diagram.

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Source: Philips Semiconductors (2004)

V_{CC} and GND are the main supply voltage input pins for the digital control inputs. The input ranges V_{CC} to GND are 2.0 V to 10.0 V for 74HC4052. The analog inputs and outputs nY0 to nY1, and nZ can swing between V_{CC} as a positive limit and V_{EE} as a negative limit. V_{CC} - V_{EE} may not exceed 10.0 V. Figure 2.5 shows the function diagram of the multiplexer operation where it consists of logic level conversion, 1 of 4 decoder and digital switch operate based on truth table show in Table 2.0.

Table 1.0: Truth Table for Multiplexer Output.

Input			CHANNEL BETWEEN
E	S1	S0	
L	L	L	nY0 and nZ
L	L	H	nY1 and nZ
L	H	L	nY2 and nZ
L	H	H	nY3 and nZ
H	X	X	none

Source: Philips Semiconductors (2004)

Note

H = HIGH voltage level
L = LOW voltage level
X = don't care.

2.9 Offset calibration.

Measurement offset is due to amplifier, A/D converter and thermocouple uncertainty offsets in the system hardware. Due to the specific measurement processing used in the hardware, the resulting measurement offset is both range- and sample time-dependent. This error is corrected using normalized offset compensation which takes these dependences into account. Measurement offsets can be using the external measurement device as reference.

CHAPTER 3

METHODOLOGY

This chapter will describe the method to be used for this project. The project consists of hardware and software design, both of part will be explained in detailed along with figure related. The flow chart below shows the steps that have been taken in doing this project.

3.1 PROJECT FLOWCHART

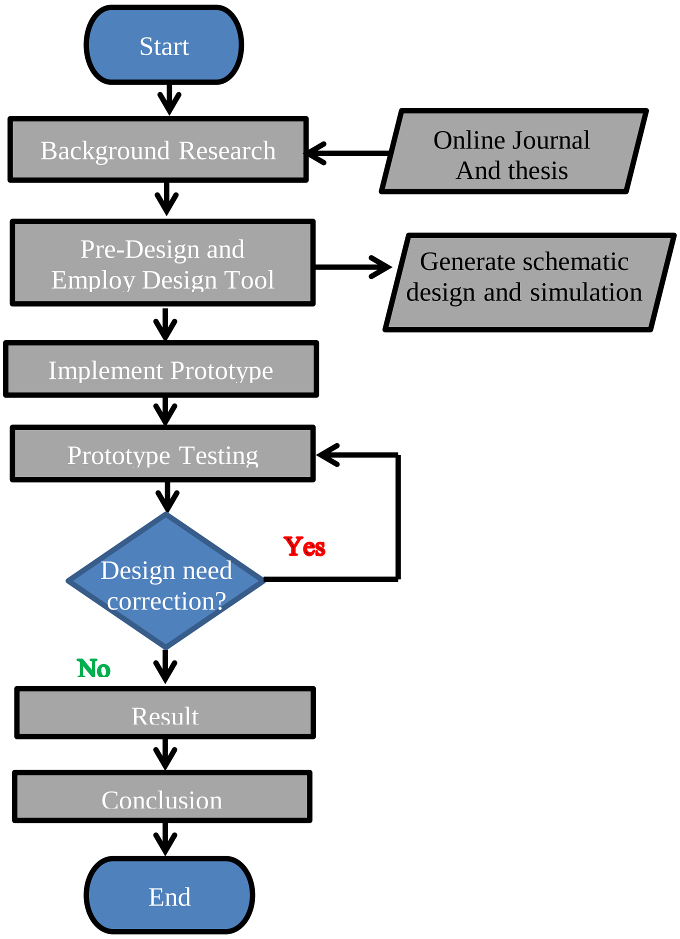

Figure 3.1: Overall project Implementation flowchart**.**

3.2 System Pre-Design

Before the fully system is developed several techniques had been used to achieve the complete system. Firstly, the part of the system is simulated using Proteus. In the first attempt using op-amp amplifier LM358 the output of the thermocouple has not fit to the thermocouple amplification and it found that this op-amp produce large signal noise. The amplification circuit of thermocouple is replaced with MAX 6675 module.

Secondly, the coding of signal between microcontroller and web server is developed to replicate the process of signal being transfer to web server using Arduino Uno, wamp server and web browser. In this process, wamp server is set up using php coding. The server fails to read data from serial port due to libraries limitation but can read the serial data on usb.

Finally, the system consisting arduino uno microcontroller, temperature sensor, computer is being integrated with readymade firmware and web application on "cloudduino.appspot.com" as shown in figure 3.2. In this stage, the web applications indicate the latency while using the serial communication over usb because the data need to process by computer before it sends to web graphical user interface. Due to this reason the project required microcontroller that directly connected to local network area and wide network area. The spark core microcontroller is used for next process.

Figure 3.2: Clouddunio Web Apps.

3.3 FRIMWARE PROGRAMMING

The firmware is the part in these devices where it provides the control program for the embedded system. Firmware is store in non-volatile memory devices such as flash memory, ROM or EPROM of the microcontroller.

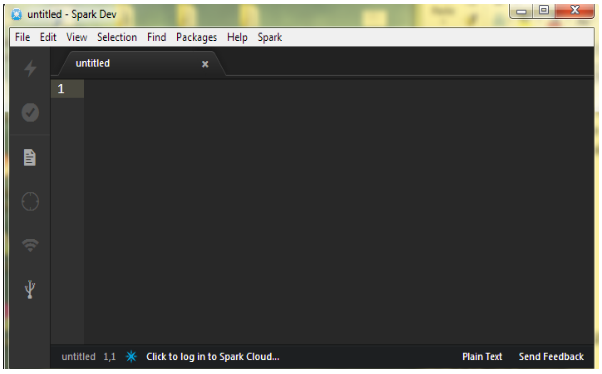

Figure 3.3: Spark DEV IDE.

The firmware is coded in c language using Spark Dev IDE shown in figure 3.2 and then the codes are being flashed into the microcontroller trough USB or WIFI connection. The device needs to be claimed using its security token before the user can start the process of flashing the code.

3.4 HARDWARE DESIGN

3.3.1 Block Diagram.

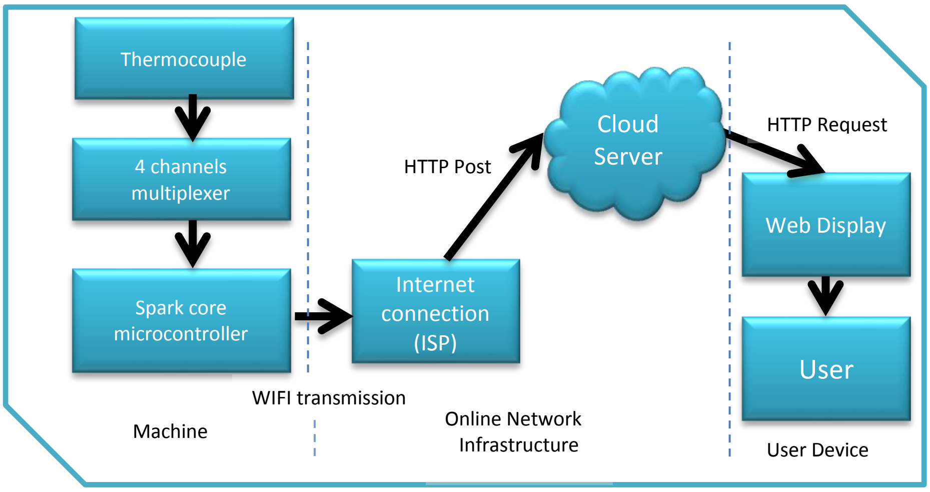

Figure 3.4: Block Diagram of the remote monitoring system.